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Ueda et al.

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(54) **CONNECTOR**

(71) Applicant: **Japan Aviation Electronics Industry, Limited**, Tokyo (JP)

(72) Inventors: **Kouhei Ueda**, Tokyo (JP); **Masaaki Takaku**, Tokyo (JP); **Yohei Yokoyama**, Tokyo (JP); **Kentaro Toda**, Tokyo (JP)

(73) Assignee: **JAPAN AVIATION ELECTRONICS INDUSTRY, LIMITED**, Tokyo (JP)

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(30) **Foreign Application Priority Data**

Jul. 8, 2014 (JP) 2014-140718

(51) **Int. Cl.**
H01R 13/648 (2006.01)
H01R 13/6596 (2011.01)
H01R 12/72 (2011.01)

(52) **U.S. Cl.**
CPC ***H01R 13/6596*** (2013.01); ***H01R 12/724*** (2013.01)

(58) **Field of Classification Search**
CPC H01R 12/7052; H01R 13/6594; H01R 12/707; H01R 23/6873
See application file for complete search history.

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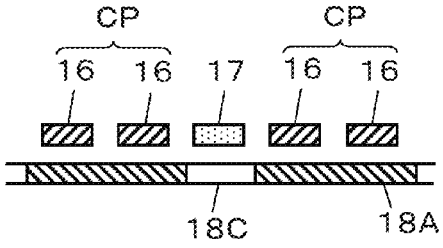
Primary Examiner — Xuong Chung Trans
(74) *Attorney, Agent, or Firm* — Muncy, Geissler, Olds & Lowe, P.C.

(57) **ABSTRACT**

A connector includes a plurality of signal contacts and a plurality of non-signal contacts arranged on at least one contact array plane, a ground plate disposed on a ground plane parallel to the contact array plane so as to face the plurality of signal contacts and the plurality of non-signal contacts, and an insulator which holds the plurality of signal contacts, the plurality of non-signal contacts and the ground plate, at least one of the non-signal contacts being disposed between each of the signal contacts and other of the signal contacts, the ground plate having at least one opening at a location facing the at least one of the non-signal contacts disposed between each of the signal contacts and other of the signal contacts, none of the signal contacts being disposed on the ground plane.

16 Claims, 9 Drawing Sheets



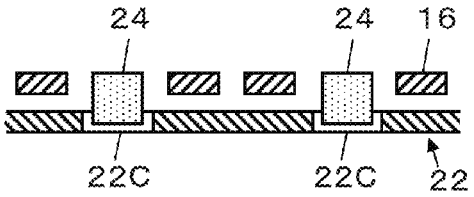


FIG. 1

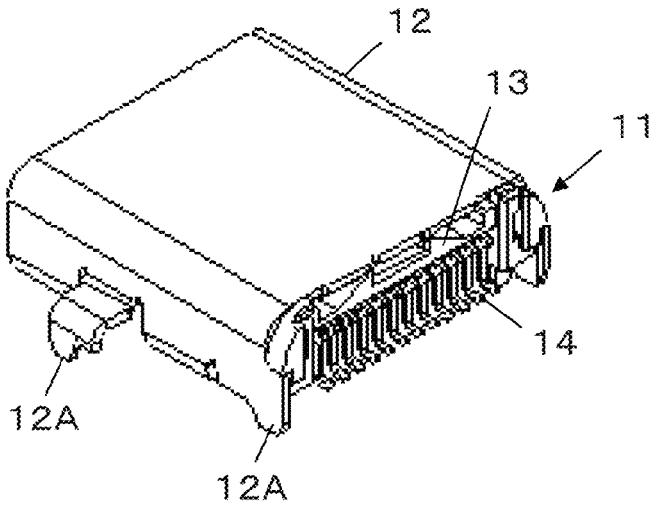


FIG. 2

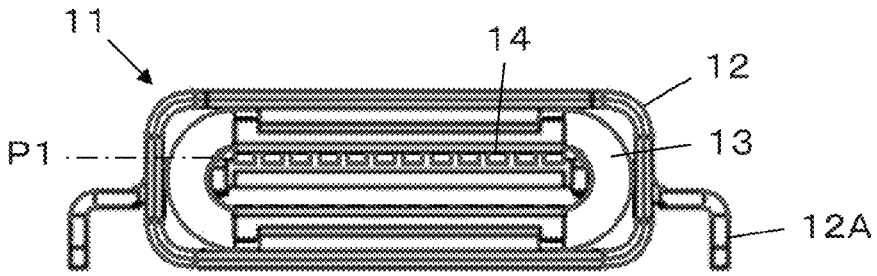


FIG. 3

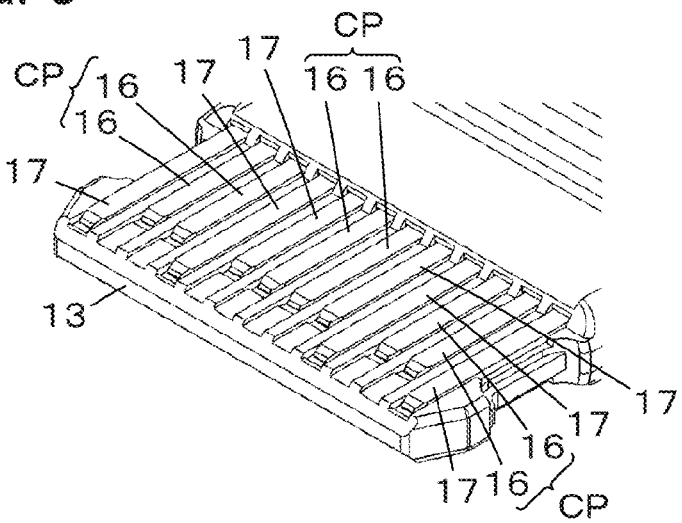


FIG. 4

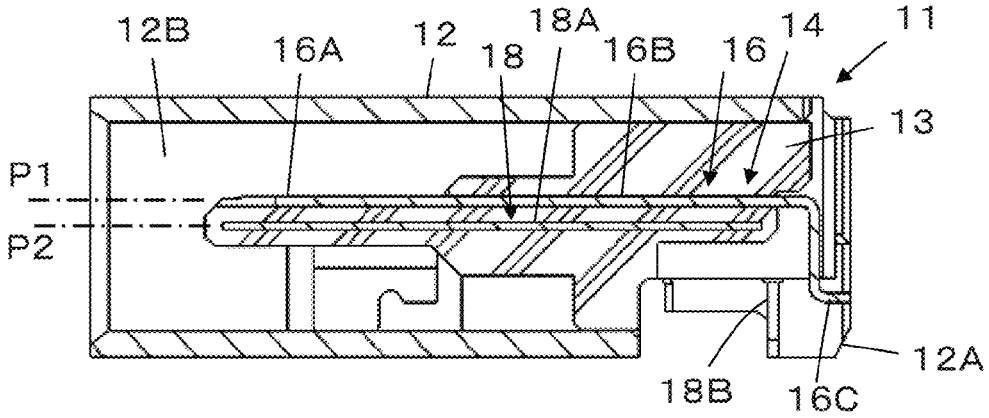


FIG. 5

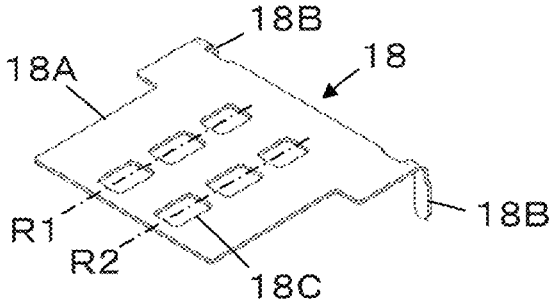


FIG. 6

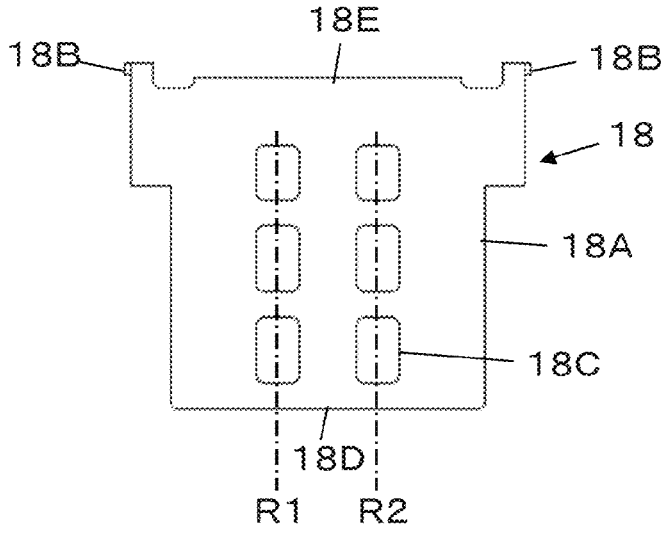


FIG. 7

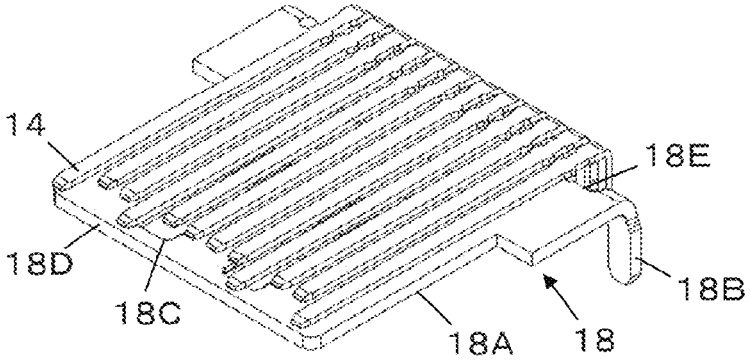


FIG. 8

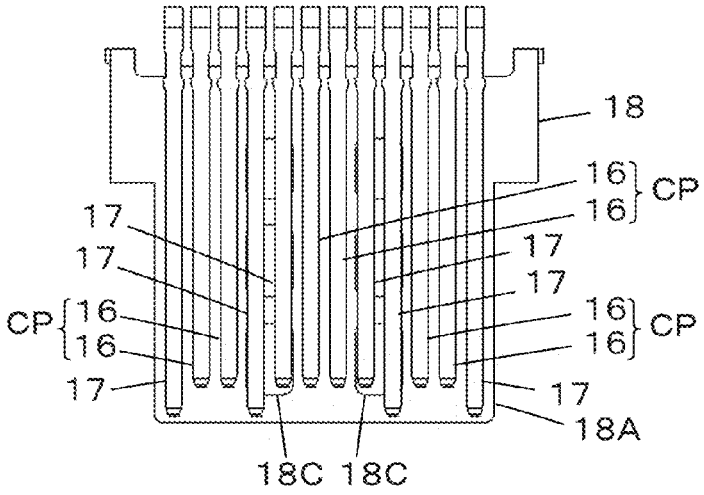


FIG. 9

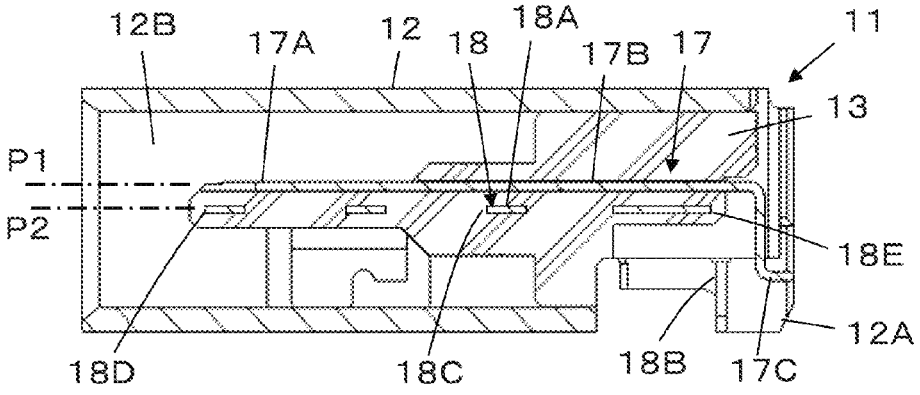


FIG. 10

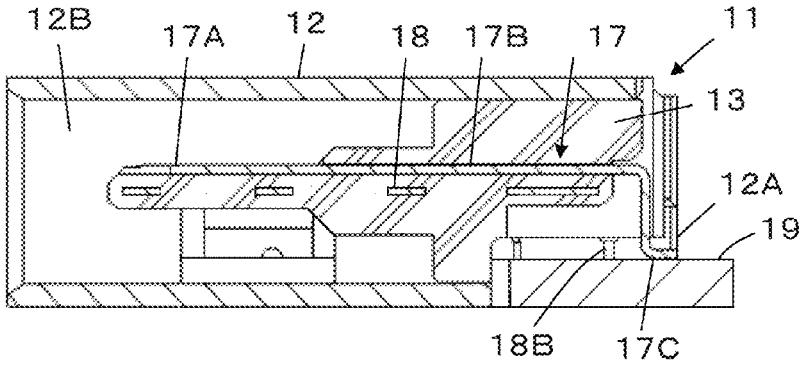


FIG. 11

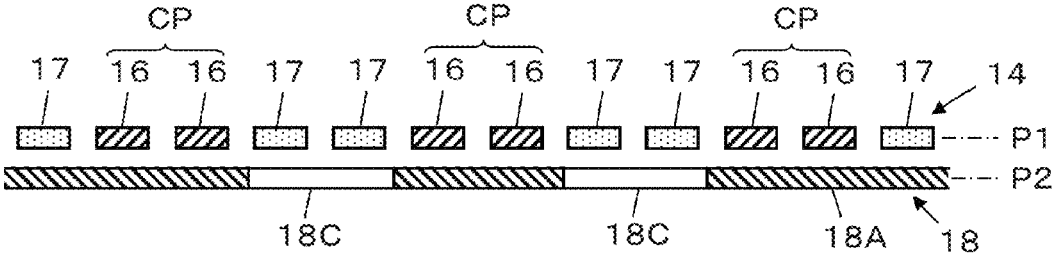


FIG. 12A

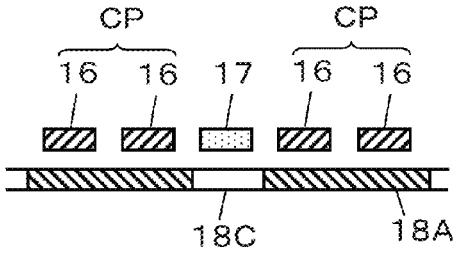


FIG. 12B

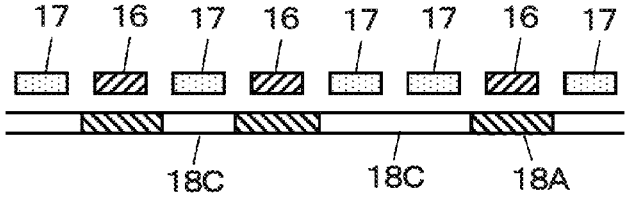


FIG. 13A

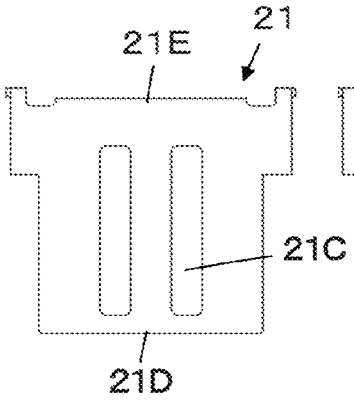


FIG. 13B

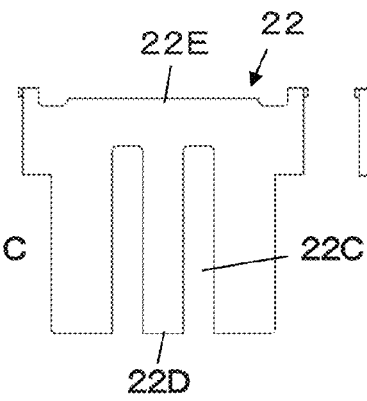


FIG. 13C

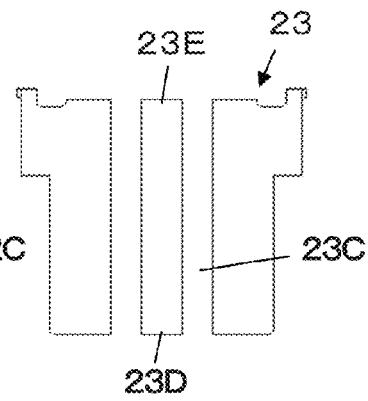
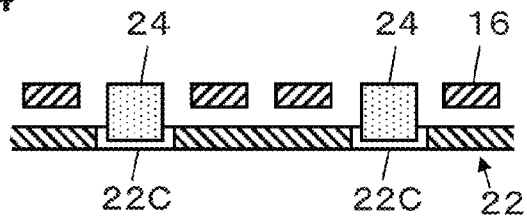


FIG. 14



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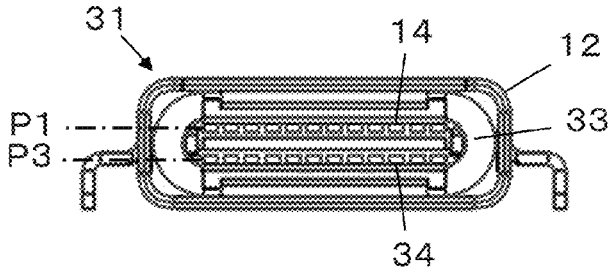


FIG. 16

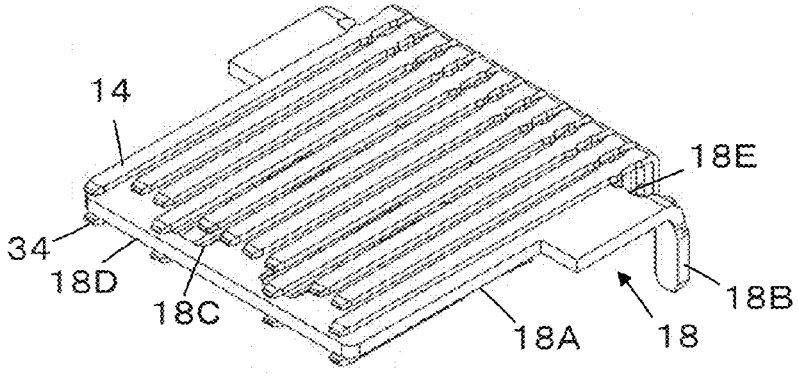


FIG. 17

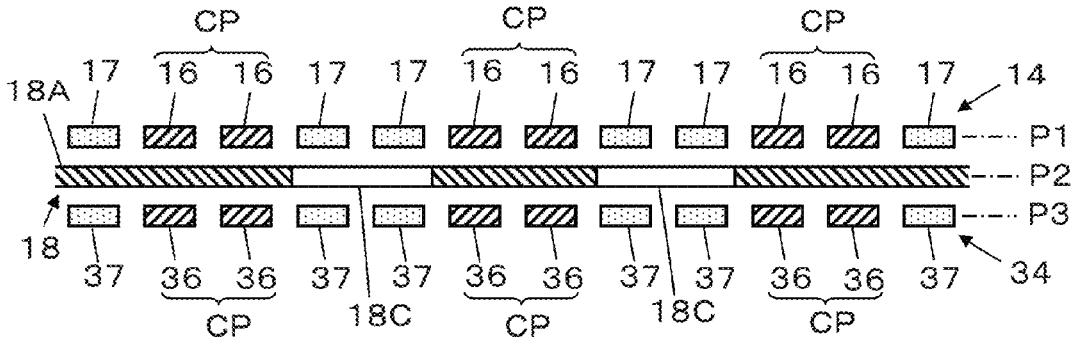


FIG. 18

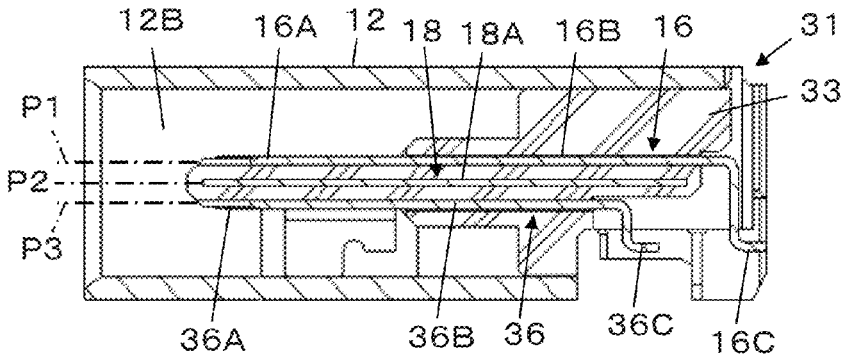


FIG. 19

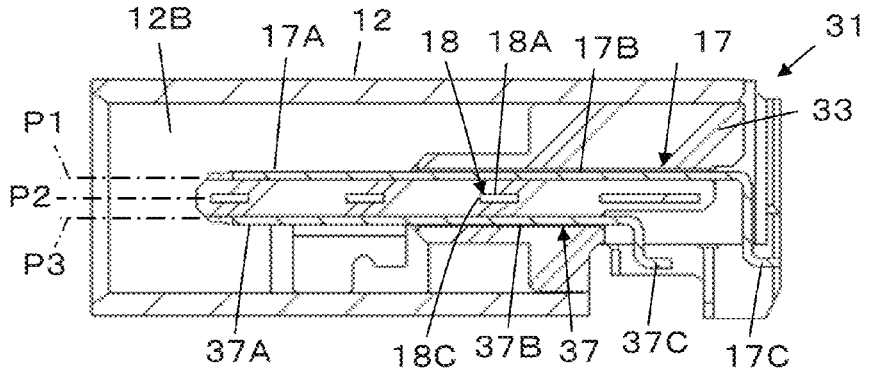


FIG. 20

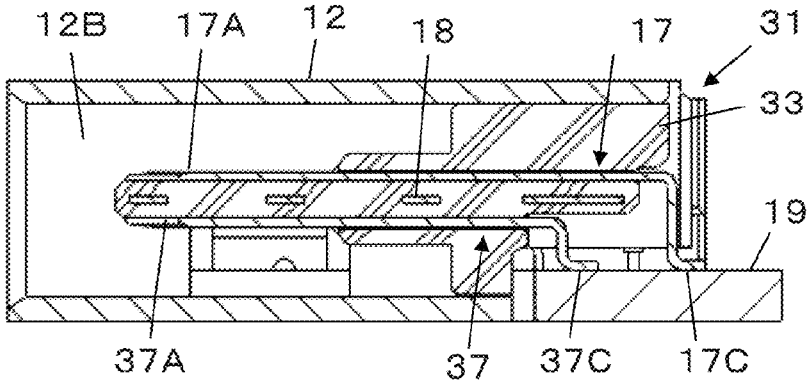


FIG. 21

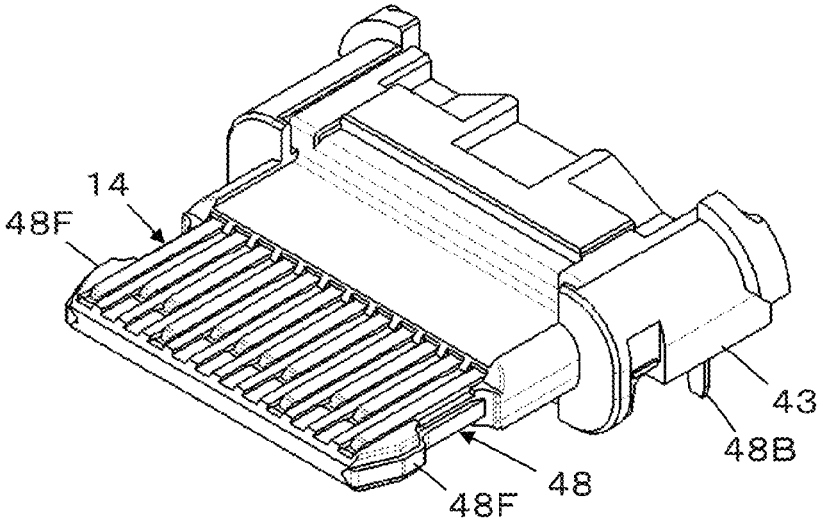


FIG. 22

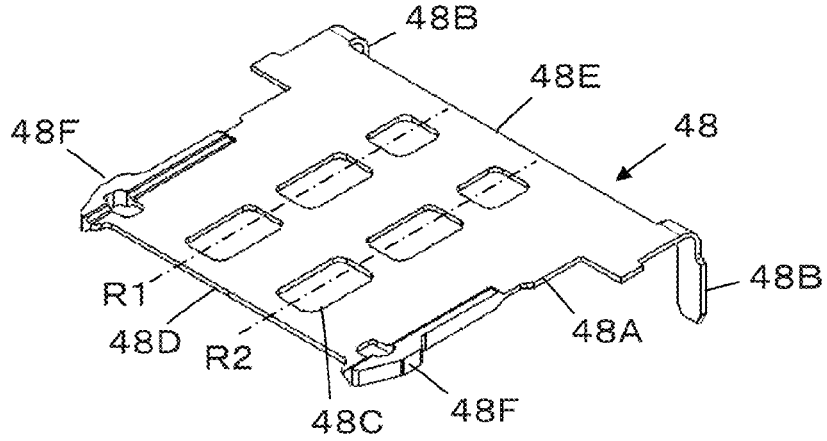


FIG. 23

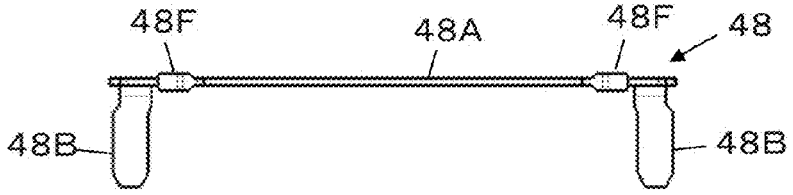


FIG. 24

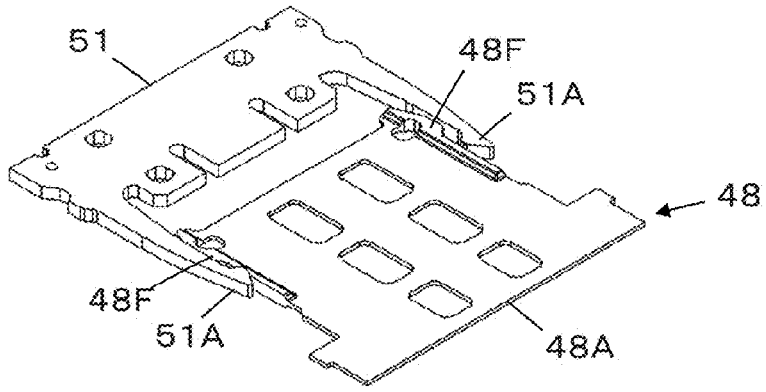


FIG. 25

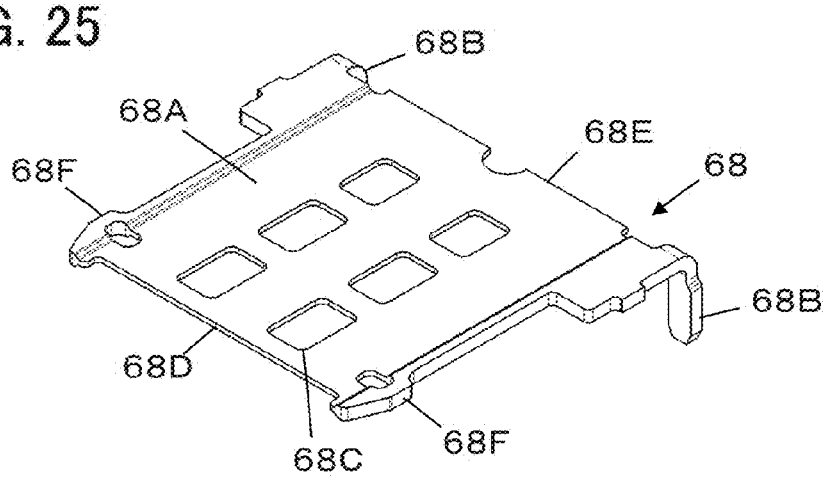


FIG. 26

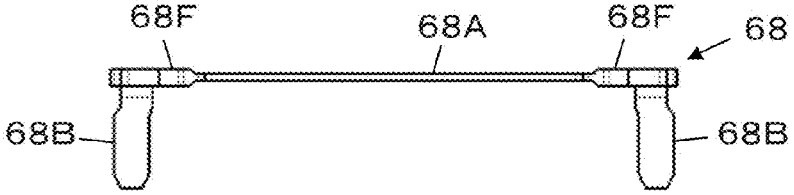


FIG. 27

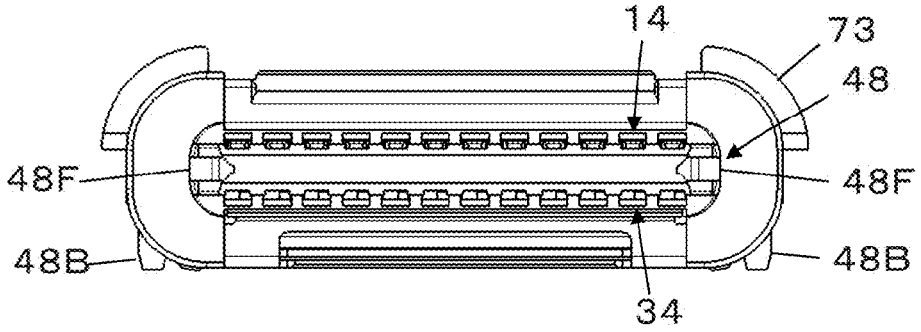


FIG. 28

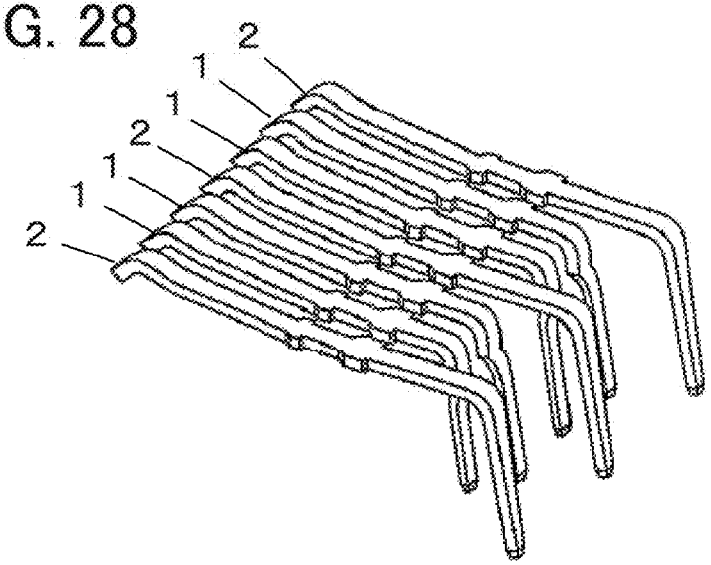
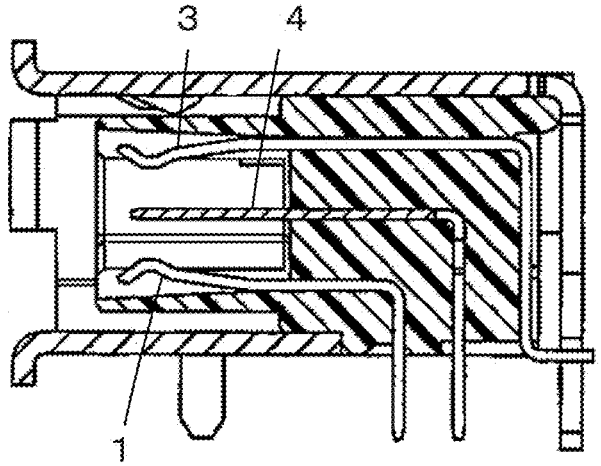


FIG. 29



CONNECTOR

BACKGROUND OF THE INVENTION

The present invention relates to a connector, and more particularly, to a connector having signal contacts that transmit/receive signals to/from a counter connector, and non-signal contacts adapted for non-signal purposes such as power supply, and ground connection.

In general, in a connector adapted to transmit/receive signals and power supply to/from external apparatuses, a plurality of contacts including signal contacts for signal transmission, and non-signal contacts to be used for non-signal purposes such as power supply and ground connection, are arranged in one or more arrays. In such cases, in order to suppress cross-talk in signals transmitted at high-speed through the signal contacts, an arranging scheme is employed, for example, in which a non-signal contact is inserted between one signal contact and other signal contact so that the space between the signal contacts can be widened.

However, in recent years, with a decrease in size and an increase in density of electronic devices such as portable devices and information devices, connectors are also required to reduce in size and thus the space between two adjacent contacts in a connector is decreased as well. Therefore it becomes difficult to satisfactorily suppress cross-talk, only by widening the space between the signal contacts in a certain limited range.

For example, JP 2008-41656 A discloses a connector in which contacts are arranged in two rows of an upper row and a lower row. As shown in FIG. **28**, in the lower row, a ground contact **2** is disposed adjacent to two signal contacts **1** that constitute a differential signal contact pair, and as shown in FIG. **29**, a ground plate **4** extending in a connector fitting direction is disposed between the signal contacts **1** and the ground contact **2** in the lower row and signal contacts **3** in the upper row. In this way, the circumference of the differential signal contact pair is encompassed by the ground contact **2** and the ground plate **4** so as to improve cross-talk suppression.

However, for example, in a connector in which the contact arranging pitch is reduced to about 0.5 mm or less, and a high speed transmission of 5 Gbps (gigabits per second) or more is enabled, there is a problem in which cross-talk is not satisfactorily suppressed even if the circumference of signal contacts is encompassed by a ground contact and a ground plate.

SUMMARY OF THE INVENTION

The present invention is made to solve the above-mentioned problems in the prior art and an object thereof is to provide a connector capable of suppressing the occurrence of cross-talk, while achieving a decrease in size and high speed transmission.

The inventors of the present invention have conducted intensive studies and have found that in a connector which is small in size and performs high speed signal transmission, when a ground contact or a power supply contact is disposed between a pair of signal contacts, and a ground plate extending in a connector fitting direction is disposed parallel to these contacts, cross-talk occurs between contacts, in a portion of the pair of signal contacts for high speed transmission, extending in the connector fitting direction, through the ground plate disposed parallel thereto.

Therefore, a connector according to the present invention comprises a plurality of signal contacts and a plurality of non-signal contacts arranged on at least one contact array plane, a ground plate disposed on a ground plane parallel to the contact array plane so as to face the plurality of signal contacts and the plurality of non-signal contacts, and an insulator which holds the plurality of signal contacts, the plurality of non-signal contacts and the ground plate, wherein at least one of the non-signal contacts is disposed between each of the signal contacts and other of the signal contacts, wherein the ground plate has at least one opening at a location facing the at least one of the non-signal contacts disposed between each of the signal contacts and other of the signal contacts, and wherein none of the signal contacts are disposed on the ground plane.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1** and **2** are a perspective view and a front view, illustrating a connector according to Embodiment 1 of the present invention, respectively.

FIG. **3** is a partial perspective view, illustrating contacts held by an insulator in the connector according to Embodiment 1.

FIG. **4** is a cross-sectional view of the connector according to Embodiment 1, taken by cutting at a location of the signal contacts.

FIGS. **5** and **6** are a perspective view and a plan view, illustrating a ground plate used in the connector according to Embodiment 1, respectively.

FIGS. **7** and **8** are a perspective view and a plan view, illustrating the contacts and the ground plate in the connector according to Embodiment 1, respectively.

FIG. **9** is a cross-sectional view of the connector according to Embodiment 1, taken by cutting at a location of non-signal contacts.

FIG. **10** is a cross-sectional view illustrating the connector according to Embodiment 1, as mounted on a substrate.

FIG. **11** is a partial front cross-sectional view, showing a positional relationship between the contacts and the ground plate in the connector according to Embodiment 1.

FIGS. **12**A and **12**B are partial front cross-sectional views each illustrating a positional relationship between contacts and a ground plate of a connector according to a variation example and other variation of Embodiment 1.

FIGS. **13**A to **13**C are plan views of ground plates used in a connector according to Embodiment 2.

FIG. **14** is a partial front cross-sectional view illustrating a positional relationship between the contacts and the ground plate in the connector according to Embodiment 2.

FIG. **15** is a front view illustrating a connector according to Embodiment 3.

FIG. **16** is a perspective view illustrating contacts and a ground plate in the connector according to Embodiment 3.

FIG. **17** is a partial front cross-sectional view illustrating a positional relationship between the contacts and the ground plate in the connector according to Embodiment 3.

FIG. **18** is a cross-sectional view of the connector according to Embodiment 3, taken by cutting at a location of signal contacts.

FIG. **19** is a cross-sectional view illustrating the connector according to Embodiment 3, taken by cutting at a location of non-signal contacts.

FIG. **20** is a cross-sectional view illustrating the connector according to Embodiment 3, as mounted on a substrate.

FIG. **21** is a perspective view illustrating a configuration of a connector according to Embodiment 4, in which a metal shell is eliminated.

FIGS. **22** and **23** are a perspective view and a front view of a ground plate used in the connector according to Embodiment 4, respectively.

FIG. **24** is a perspective view, illustrating a behavior of a lock receiving section of the ground plate and a lock section of a counter connector, when the counter connector fits into the connector according to Embodiment 4.

FIGS. **25** and **26** are a perspective view and a front view, illustrating a ground plate used in a connector according to a variation example of Embodiment 4, respectively.

FIG. **27** is a front view, illustrating the connector according to other variation example of Embodiment 4, in which a metal shell is eliminated.

FIG. **28** is a perspective view, illustrating contacts in a prior art connector.

FIG. **29** is a cross-sectional view, illustrating a prior art connector.

DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, embodiments of the present invention will be described with reference to the accompanying drawings.

Embodiment 1

FIG. **1** shows a connector **11** according to Embodiment 1. The connector **11** is a receptacle connector to be fixed to a substrate in electronic devices such as portable devices and information devices. The connector **11** has a metal shell **12**, an insulator **13** disposed inside the metal shell **12**, and contacts **14** held by the insulator **13**.

The metal shell **12** covers an outer periphery portion of the insulator **13**, excluding a front surface section and a back surface section of the insulator **13**, facing the fitting direction of the connector **11**. Shell leg sections **12**A to be mounted to the substrate are formed protrudingly in a direction perpendicular to the fitting direction of the connector **11**.

As shown in FIG. **2**, contacts **14** are held by the insulator **13**, with the contacts **14** being arranged in a line on a contact array plane P**1**. These contacts **14** consist of signal contacts **16** configured to transmit and receive signals to and from a counter connector, and non-signal contacts **17** to be used for non-signal purposes, as shown in FIG. **3**. The non-signal contacts **17** include, for example, a power supply contact, a ground contact, and a contact for detecting connector fitting status. Three sets of differential signal contact pairs CPs, each consisting of two signal contacts **16** adjacent to each other, are formed and two non-signal contacts **17** are disposed between each differential signal contact pair CP and other differential signal contact pair CP.

FIG. **4** shows a cross-sectional view of the connector **11**, taken by cutting at a location of one of the signal contacts **16**. Inside the front end of the metal shell **12**, a counter connector housing section **12**B to which a counter connector is inserted is formed. Inside the back end of the metal shell **12**, the insulator **13** is housed.

Each of the signal contacts **16** has a contact section **16**A at its front end exposing to the counter connector housing section **12**B, an insulator fixing section **16**B in its middle portion embedded and fixed in the insulator **13**, and a substrate mounting section **16**C at its back end to be mounted and fixed to a substrate. The contact section **16**A is to be in contact with a contact of a counter connector inserted in the counter connector housing section **12**B. The contact section **16**A and the insulator fixing section **16**B are extended flatly on the contact array plane P**1**. The substrate mounting section **16**C to be connected to the insulator fixing section **16**B protrudes to a back section of the insulator **13**, and has a shape bending with respect to the insulator fixing section **16**B.

In addition, in the insulator **13**, a ground plate **18** is held. The ground plate **18** is formed of a metal plate extending along a ground plane P**2** parallel to the contact array plane P**1** on which the contacts **14** including the signal contacts **16** are arranged. The ground plate **18** has a plate body **18**A embedded in the insulator **13**, and a plate leg section **18**B exposed to outside from the back end of the insulator **13**. The plate body **18**A extends along the ground plane P**2**. The plate leg section **18**B, together with the shell leg section **12**A of the metal shell **12** protrudes in a direction perpendicular to the contact array plane P**1** and the ground plane P**2**.

As shown in FIG. **5**, in the plate body **18**A of the ground plate **18**, openings **18**C are formed. The openings **18**C are arranged in two rows R**1** and R**2** parallel to each other. The plate body **18**A has, as shown in FIG. **6**, a plate front end section **18**D and a plate back end section **18**E, and each of the rows R**1** and R**2** has three openings **18**C disposed between the plate front end section **18**D and the plate back end section **18**E.

As shown in FIG. **7**, the ground plate **18** described above is disposed adjacent to the contacts **14**. The openings **18**C are formed facing two non-signal contacts **17** disposed between each differential signal contact pair CP and other differential signal contact pair CP, as shown in FIG. **8**. That is, the plate body **18**A of the ground plate **18** is disposed facing all of the contacts **14** arranged on the contact array plane P**1**, and in a portion facing each of the signal contacts **16**, none of the openings **18**C are formed, while three openings **18**C are formed in a portion facing the two non-signal contacts **17** disposed between the signal contacts **16** that constitute each differential signal contact pair CP and the signal contacts **16** that constitute other differential signal contact pair CP.

Accordingly, if the connector **11** is cut at a location of the non-signal contacts **17** disposed among the three sets of differential signal contact pairs CPs, as shown in FIG. **9**, the ground plate **18** is separated by three openings **18**C.

Each of the non-signal contacts **17** is configured similarly signal contacts **16**, and has, at a front end, a contact section **17**A protruding to the counter connector housing section **12**B, has, in a middle portion, an insulator fixing section **17**B to be fixed and embedded in the insulator **13**, and has, at a back end, a substrate mounting section **17**C to be mounted and fixed to a substrate. The contact section **17**A is to be in contact with the contact of a counter connector inserted in the counter connector housing section **12**B, and the contact section **17**A and the insulator fixing section **17**B are extended flatly on the contact array plane P**1**. The substrate mounting section **17**C connected to the insulator fixing section **17**B protrudes to the back section of the insulator **13**, and has a shape bending with respect to the insulator fixing section **17**B.

In addition, the plate front end section **18**D of the ground plate **18** faces the front end of the contact section **17**A of the non-signal contact **17**, and the plate back end section **18**E faces the back end of the insulator fixing section **17**B of the non-signal contact **17** at the side of the substrate mounting section **17**C.

Accordingly, the contact sections **16**A and the insulator fixing sections **16**B of the signal contacts **16**, and the contact

sections **17**A and the insulator fixing sections **17**B of the non-signal contacts **17** extend on the contact array plane P**1**. The plate body **18**A of the ground plate **18** extending along the ground plane P**2** parallel to the contact array plane P**1** faces the contact sections **16**A and the insulator fixing sections **16**B of the signal contacts **16**, and the contact sections **17**A and the insulator fixing sections **17**B of the non-signal contacts **17**. In the plate body **18**A of the ground plate **18**, the openings **18**C are formed in a portion facing the two non-signal contacts **17** disposed between each differential signal contact pair CP and other differential signal contact pair CP. Such a connector **11** can be manufactured by insert-molding the signal contacts **16**, the non-signal contacts **17**, and the ground plate **18** with a resin that forms the insulator **13**, so that the insulator fixing sections **16**B of the signal contacts **16**, the insulator fixing section **17**B of the non-signal contacts **17**, and the plate body **18**A of the ground plate **18** are embedded in the insulator **13**, followed by press-fitting the insulator **13** into the metal shell **12**.

The connector **11** is used as mounted on a substrate **19**, as shown in FIG. **10**. The shell leg section **12**A of the metal shell **12**, and the plate leg section **18**B of the ground plate **18** are inserted in a through-hole (not shown) formed in the substrate **19**, and mounted and fixed by soldering, so that the connector **11** is mounted on the substrate **19**, and the metal shell **12** and the ground plate **18** are connected to a ground potential via the through-hole in the substrate **19**. In addition, the substrate mounting sections **16**C of the signal contacts **16**, and the substrate mounting sections **17**C of the non-signal contacts **17** are mounted and fixed to each corresponding connecting pad (not shown) on the substrate **19** by soldering, and then connected to, for example, a not shown electronic circuit mounted on the substrate **19**.

A not shown counter connector is inserted into the counter connector housing section **12**B of the metal shell **12**, and the contact sections **16**A of the signal contacts **16**, and the contact sections **17**A of the non-signal contacts **17** are made in contact with each corresponding contact of the counter connector, so that the connector is set into a fitting status, thereby enabling transmitting and receiving signals to and from external apparatuses.

At this time, as shown in FIG. **11**, each differential signal contact pair CP consisting of two adjacent signal contacts **16** is encompassed by the non-signal contacts **17** disposed on the both sides of the contact array plane P**1**, and the plate body **18**A of the ground plate **18** disposed on the ground plane P**2**, so that the occurrence of cross-talk between each differential signal contact pair CP and other differential signal contact pair CP can be suppressed.

Further, two non-signal contacts **17** are disposed between each differential signal contact pair CP and other differential signal contact pair CP, and the openings **18**C are formed in the plate body **18**A in a portion facing the two non-signal contacts **17**. Thus, for example, while the arranging pitch of the contact is reduced to about 0.5 mm or less, and high speed transmission of 5 Gbps (gigabits per second) or more is achieved, the occurrence of cross-talk between each differential signal contact pair CP and other differential signal contact pair CP through the ground plate **18** can be prevented.

As a result, a connector capable of high speed signal transmission with a high degree of accuracy, while the size of the connector is reduced, is realized.

It should be noted that while in Embodiment 1 described above, two non-signal contacts **17** are disposed between each differential signal contact pair CP and other differential signal contact pair CP, the present invention is not limited to this. As shown in FIG. **12**A one non-signal contact **17** may be disposed between each differential signal contact pair CP and other differential signal contact pair CP, so as to suppress cross-talk. In this regard, however, in order to suppress cross-talk more effectively, it is more preferable to dispose two or more non-signal contacts **17** between each differential signal contact pair CP and other differential signal contact pair CP to widen the space therebetween. In addition, three or more non-signal contacts **17** may be disposed between each differential signal contact pair CP and other differential signal contact pair CP.

Further, it is not limited to use the signal contacts **16** constituting the differential signal contact pair CP, but as shown in FIG. **12**B, one signal contact **16** may be used. One or more non-signal contacts **17** may be disposed between one signal contact **16** and other signal contact **16**, and the openings **18**C may be formed on the plate body **18**A of the ground plate **18** at a portion facing the non-signal contacts **17**, thereby the occurrence of cross-talk can be suppressed and high speed signal transmission via the signal contacts **16** can be achieved.

Further, while in Embodiment 1 described above, the plate body **18**A of the ground plate **18** has three openings **18**C between the plate front end section **18**D and the plate back end section **18**E, the number of openings **18**C is not limited to three, and the plate body **18**A of the ground plate **18** may have two or four or more openings **18**C.

Embodiment 2

While, in the around plate **18** used in Embodiment 1 described above, as shown in FIG. **6**, the openings **18**C are formed in the two rows R**1** and R**2** parallel to each other, and each of the rows R**1** and R**2** has three openings **18**C between the plate front end section **18**D and the plate back end section **18**E, the present invention is not limited to this.

For example, as shown in FIG. **13**A, a ground plate **21** having a single opening **21**C that extends from a plate front end section **21**D to a plate back end section **21**E, corresponding to the non-signal contact **17**, instead of having plural openings **21**C between the plate front end section **21**D and the plate back end section **21**E, may be used.

Also, as in a ground plate **22** shown in FIG. **13**B, the plate front end section **22**D may be notched to provide an opening **22**C with the front end being opened.

Further, as in a ground plate **23** shown in FIG. **13**C, a plate front end section **23**D and a plate back end section **23**E may be both notched to provide an opening **23**C with both front and back ends being opened.

If the front end of the opening **22**C is opened, as in the ground plate **22**, a power supply contact **24** that is formed to be thicker than the signal contacts **16**, for example, as shown in FIG. **14**, can be disposed corresponding to the opening **22**C and used as one of the non-signal contacts **17**. The presence of the opening **22**C can prevent short-circuiting between the power supply contact **24** and the ground plate **22** even if the surface heights of the contact section **16**A of the signal contacts **16** and the contact section **17**A of the non-signal contacts **17** exposed outside of the insulator **13** are aligned. Thereby, it is possible to increase the cross area of the power supply contact **24** to increase the current capacity.

Similarly, by using the ground plate **23** having the opening **23**C with the both front and back ends being opened, it is also possible to easily increase the cross area of the power supply contact **24** to increase the current capacity.

It should be noted that, in case a ground plate in which no openings are formed is disposed adjacent to contacts, as in a prior art connector, when a certain contact is formed to be thick, in order to align the surface height of the contacts exposing outside of an insulator, the facing surface of the contacts comes close to the ground plate depending on the thickness, causing a potential short-circuiting. Therefore, it has been difficult to increase the current capacity by having a thicker power supply contact.

In this regard however, when insert-molding the ground plates **18** and **21-23** together with a resin used for forming the insulator **13**, the ground plates **18** and **21-23** are required to have a certain necessary strength to prevent displacement or deformation against the injection pressure of the resin. Therefore, in terms of strength, the ground plates **18** and **21** in which the front ends of the openings **18**C and **21**C are closed are advantageous. In particular, since the ground plate **18** used in Embodiment 1 has three openings **18**C disposed between the plate front end section **18**D and the plate back end section **18**E, the necessary strength can be ensured even if it is formed from a thin metal plate.

Embodiment 3

FIG. **15** shows a connector **31** according to Embodiment 3. The connector **31** uses an insulator **33**, instead of the insulator **13** in the connector **11** in Embodiment 1. The contacts **14** arranged on the contact array plane P**1** and contacts **34** arranged on a contact array plane P**3** are held by the insulator **33**. The two contact array planes P**1** and P**3** are disposed parallel to each other, so that the contacts **14** and **34** are arranged in two rows of an upper row and a lower row, respectively.

In the insulator **33**, the ground plate **18** used in Embodiment 1 is held. As shown in FIG. **16**, the ground plate **18** is disposed adjacent to each of the contacts **14** and the contacts **34**, and between the contacts **14** and the contacts **34**.

As shown in FIG. **17**, the contact array plane P**1** and the contact array plane P**3** are disposed at both sides of the ground plane P**2** in which the plate body **18**A of the ground plate **18** is disposed. The contacts **34** arranged on the contact array plane P**3** are aligned symmetry to the alignment of the contacts **14** arranged on the contact array plane P**1** with respect to the ground plane P**2**. That is, the contacts **34** can be divided in two: signal contacts **36** for signal transmission to and from a counter connector; and non-signal contacts **37** used for non-signal purposes such as power supply, ground connection, and detection of connector-fitting status. The signal contacts **36** are disposed at a location corresponding to the signal contacts **16** on the contact array plane P**1**, and the non-signal contacts **37** are disposed at a location corresponding to the non-signal contacts **17** on the contact array plane P**1**.

The differential signal contact pair CP is formed of the two signal contacts **36** adjacent to each other, and two non-signal contacts **37** are disposed between each differential signal contact pair CP and other differential signal contact pair CP.

Therefore, there are no openings **18**C in the plate body **18**A at a location facing the signal contacts **16** on the contact array plane P**1**, and the signal contacts **36** on the contact array plane P**3**. The openings **18**C are located in the plate body **18**A at a portion facing the non-signal contacts **17** disposed between the signal contacts **16** and the signal contacts **16** on the contact array plane P**1**, and the non-signal contacts **37** disposed between the signal contacts **36** and the signal contacts **36** on the contact array plane P**3**.

FIG. **18** shows a cross-sectional view of the connector **31** taken by cutting at a location of the signal contacts **16** and **36**. Each of the signal contacts **36** has, similar to the signal contacts **16**, at a front end, a contact section **36**A exposed to the counter connector housing section **12**B, has in a middle portion, an insulator fixing section **36**B to be fixed to the insulator **33**, and has in a back end, a substrate mounting section **36**C. The contact section **36**A and the insulator fixing section **36**B are extended flatly on the contact array plane P**3**. Then, the plate body **18**A of the ground plate **18** faces the contact section **16**A and the insulator fixing section **16**B of the signal contacts **16**, and the contact section **36**A and the insulator fixing section **36**B of the signal contacts **36**.

Also, FIG. **19** shows a cross-sectional view of the connector **31**, taken by cutting at a location of the non-signal contacts **17** and **37**. Each of the non-signal contacts **37** has, similar to the signal contacts **36**, at a front end, a contact section **37**A exposed to the counter connector housing section **12**B, has in a middle portion, an insulator fixing section **37**B fixed to the insulator **33**, and has at a back end, a substrate mounting section **37**C. The contact section **37**A and the insulator fixing section **37**B are extended flatly on the contact array plane P**3**. The plate body **18**A of the ground plate **18** faces the contact section **17**A and the insulator fixing section **17**B of the non-signal contacts **17**, and the contact section **37**A and the insulator fixing section **37**B of the non-signal contacts **37**. In the plate body **18**A of the ground plate **18**, the openings **18**C are formed at a location facing the non-signal contacts **17** and **37**.

The connector **31** is mounted on the substrate **19**, as shown in FIG. **20**. The substrate mounting sections **16**C of the signal contacts **16** and the substrate mounting sections **17**C of the non-signal contacts **17**, and the substrate mounting sections **36**C of the signal contacts **36** and the substrate mounting sections **37**C of the non-signal contacts **37** are mounted and fixed by soldering to corresponding connecting pads (not shown) on the substrate **19**, respectively.

The counter connector is inserted into the counter connector housing section **12**B of the metal shell **12**, so that the contact sections **16**A of the signal contacts **16** and the contact sections **17**A of the non-signal contacts **17**, and the contact sections **36**A of the signal contacts **36** and the contact sections **37**A of the non-signal contacts **37** are made to contact to the corresponding contacts of the counter connector, respectively, making the connector to be in fitting status, to allow power transmitting/receiving and signal transmission, and the like, to be performed to/from the external apparatuses.

At this time, as shown in FIG. **17**, each differential signal contact pair CP consisting of two adjacent signal contacts **16** is encompassed by the non-signal contacts **17** disposed on the both sides of the signal contacts **16** on the contact array plane P**1**, and the plate body **18**A of the ground plate **18**, disposed on the ground plane P**2**. Similarly, each differential signal contact pair CP consisting of two adjacent signal contacts **36** is encompassed by the non-signal contacts **37** disposed on the both sides of the signal contacts **16** on the contact array plane P**3**, and the plate body **18**A of the ground plate **18**, disposed on the ground plane P**2**. Therefore, the occurrence of cross-talk between each differential signal contact pair CP and other differential signal contact pair CP can be suppressed.

Further, since the two non-signal contacts **17** or **37** are disposed between each differential signal contact pair CP and other differential signal contact pair CP, and the openings **18**C are formed in the plate body **18**A at a portion facing the non-signal contacts **17** or **37**, the occurrence of cross-talk

between each differential signal contact pair CP and other differential signal contact pair CP through the ground plate **18** can be prevented even if the arranging pitch of the contacts is reduced and high speed signal transmission is performed.

It should be noted that, also in Embodiment 3, the number of the non-signal contacts **17** or **37** to be disposed between each differential signal contact pair CP and other differential signal contact pair CP is not limited to two, but one or three or more non-signal contacts **17** or **37** may be disposed between each differential signal contact pair CP and other differential signal contact pair CP.

In addition, the signal contacts **16** and **36** are not limited to those constituting the differential signal contact pair CP. For example, one or more non-signal contacts **17** may be disposed between one signal contact **16** and other signal contact **16**, and one or more non-signal contacts **37** may be disposed between one signal contact **36** and other signal contact **36**, and the openings **18**C may be formed in the plate body **18**A of the ground plate **18**, at a location facing the non-signal contacts **17** and **37**, thereby, high speed signal transmission can be achieved through the signal contacts **16** and **36**, while suppressing the occurrence of cross-talk.

While, in Embodiment 3 described above, the contacts **14** arranged on the contact array plane P**1** and the contacts **34** arranged on the contact array plane P**3** are disposed symmetrically to each other with respect to the ground plane P**2**, symmetrical arrangement is not necessarily required. However, preferably, the non-signal contacts **17** and **37** are disposed at a location facing the openings **18**C on the plate body **18**A of the ground plate **18**, and there are no openings **18**C at a location facing the signal contacts **16** and **36**.

Also in Embodiment 3, similar to Embodiment 2, various ground plates **21**-**23** shown in FIGS. **13**A-**13**C may be used.

Embodiment 4

FIG. **21** shows a configuration of a connector according to Embodiment 4, in which a metal shell is eliminated. This connector uses an insulator **43** and a ground plate **48** instead of the insulator **13** and the ground plate **18** used in the connector **11** in Embodiment 1, respectively. The contacts **14** and the ground plate **48** are held by the insulator **43**.

The ground plate **48** has an approximately rectangular shape, as shown in FIG. **22**, similar to the ground plate **18** of the connector **11** in Embodiment 1. The ground plate **48** has an plate body **48**A facing the contacts **14**, and a pair of plate legs **48**B protruding from both side sections of a plate back end section **48**E, and bending perpendicularly with respect to the plate body **48**A. Openings **48**C are formed in the plate body **48**A, arranged in two rows R**1** and R**2** extending from a plate front end section **48**D to the plate back end section **48**E.

In addition, in the ground plate **48**, a pair of lock receiving sections **48**F is formed, protruding from the both side sections of the plate body **48**A at the side of the plate front end section **48**D, laterally, that is, protruding toward outside of the arranging direction of the contacts **14**. These lock receiving sections **48**F are adapted to catch the lock section of a counter connector when fitting into the counter connector, and are thicker than the plate body **48**A, as shown in FIG. **23**.

The plate body **48**A is then embedded in the insulator **43**, with the plate body **48**A facing and close to the contacts **14**. The ground plate **48** is held by the insulator **43** so that the pair of plate legs **48**B and the pair of lock receiving sections **48**F are exposed from the insulator **43**. As shown in FIG. **21**, the pair of plate legs **48**B is exposed downwardly from the back end of the insulator **43**. The pair of lock receiving sections **48**F is exposed laterally from the both side sections of the front end of the insulator **43**.

It should be noted that the openings **48**C of the ground plate **48**, similar to the openings **18**C of the ground plate **18** in the connector **11** in Embodiment 1, are formed in a location facing the non-signal contacts **17** that are disposed between one signal contact **16** and other signal contact **16** among the contacts **14**.

As shown in FIG. **24**, the counter connector to be fitted to the connector in Embodiment 4 has a lock member **51**. A pair of lock sections **51**A is formed protruding forwardly from the both side sections of the lock member **51**. When the counter connector is fitted into the connector in Embodiment 4, the pair of lock sections **51**A of the counter connector is made to contact with the pair of lock receiving sections **48**F of the ground plate **48**, so as to be deformed toward outside. The pair of deformed lock sections **51**A of the counter connector is then latched by the lock receiving section **48**F, after over-passing the lock receiving section **48**F, so that the fitting status between the counter connector and the connector in Embodiment 4 can be maintained.

For a simplicity purpose, the pair of plate legs **48**B of the ground plate **48** is not shown in FIG. **24**.

In addition, by pulling the counter connector out of the connector in Embodiment 4, each lock section **51**A is unlatched from the corresponding lock receiving section **48**F to release the fitting status between the counter connector and the connector in Embodiment 4.

As described above, the lock receiving section **48**F of the ground plate **48** has a thickness greater than the thickness of the plate body **48**A.

High speed signal transmission can be achieved with high accuracy, regardless of the thickness of the plate body **48**A, as long as the distance between the surface of the plate body **48**A and the contacts **14** is kept to a certain necessary value, when disposing the plate body **48**A. Therefore, by forming the plate body **48**A to be thinner than the lock receiving section **48**F, the size of the connector can be decreased.

On the other hand, the lock receiving section **48**F may be formed to be thicker than the plate body **48**A, so that a mechanical strength enough to catch the lock section **51**A of the counter connector can be ensured. Also, when the thickness of the lock receiving section **48**F is great enough, the latching between the lock receiving section **48**F and the lock section **51**A is ensured and fitting status can be maintained even if there is misalignment in a height direction with the lock section **51**A of the counter connector. In addition, by forming the lock receiving section **48**F to be thicker, the abrasion resistance of the lock receiving section **48**F can be improved, and the stress concentration to the lock section **51**A of the counter connector can be suppressed, and therefore, even if fitting and releasing operations are repeated to the counter connector, deterioration of the fitting retention performance caused by the lock section **51**A can be prevented, thereby a longer life of the connector can be achieved.

Instead of the ground plate **48** shown in FIG. **22**, a ground plate **68** shown in FIGS. **25** and **26** may be used. In the ground plate **48**, only the both side sections of the plate body **48**A in the side of the plate front end section **48**D have a thickness greater than the thickness of the plate body **48**A, and at that location, the lock receiving section **48**F is formed. In contrast, in the ground plate **68**, a whole area in the both side sections of a plate body **68**A from a plate front end section **68**D to a plate back end section **68**E, and a pair of

plate legs **68**B protruding from the both side sections of the plate back end section **68**E have a thickness greater than the thickness of the plate body **68**A, and lock receiving sections **68**F are formed at the both side sections of the plate body **68**A in the side of the plate front end section **68**D.

That is, the central area of the plate body **68**A in which openings **68**C are disposed, is formed to be thin and other areas are formed to be thicker than the central area of the plate body **68**A.

Even if such a ground plate **68** is used, the lock receiving sections **68**F can catch the lock sections **51**A of the counter connector and maintain fitting status with the counter connector.

It should be noted that while the ground plate **48** shown in FIG. **22** has three openings **48**C between the plate front end section **48**D and the plate back end section **48**E, corresponding to the non-signal contacts **17** and the ground plate **68** shown in FIG. **25** also has three openings **68**C between the plate front end section **68**D and the plate back end section **68**E, one opening **48**C extending from the plate front end section **48**D to the plate back end section **48**E, or one opening **68**C extending from the plate front end section **68**D to the plate back end section **68**E may be used as in Embodiment 2 shown in FIGS. **13**A-**13**C.

In addition, the ground plate **48** shown in FIG. **22**, or the ground plate **68** shown in FIG. **25** may also be used in a connector, such as the connector **31** in Embodiment 3, in which the contacts **14** and **34** are arranged in the pair of contact array planes P**1** and P**3** disposed at the both sides of the ground plane P**2**, respectively.

For example, a configuration may be achieved, as shown in FIG. **27**, in which the ground plate **48** and the contacts **14** and **34** are held by an insulator **73**, the pair of plate legs **48**B of the ground plate **48** is exposed to outside from the back end of the insulator **73** respectively, and the pair of lock receiving sections **48**F protrudes laterally from the both side sections of the front end of the insulator **73** respectively so as to be exposed.

Even with such configuration, it is possible to maintain the fitting status to the counter connector by making the lock receiving sections **48**F to catch the lock sections **51**A of the counter connector.

What is claimed is:

1. A connector comprising:

a plurality of signal contacts and a plurality of non-signal contacts arranged on at least one contact array plane;

a ground plate disposed on a ground plane parallel to the contact array plane so as to face the plurality of signal contacts and the plurality of non-signal contacts; and

an insulator which holds the plurality of signal contacts, the plurality of non-signal contacts and the ground plate,

wherein at least one of the non-signal contacts is disposed between each of the signal contacts and other of the signal contacts,

wherein the ground plate has at least one opening at a location facing the at least one of the non-signal contacts disposed between each of the signal contacts and other of the signal contacts, and

wherein none of the signal contacts are disposed on the ground plane.

2. The connector according to claim **1**, wherein two or more non-signal contacts out of the plurality of non-signal contacts are disposed between each of the signal contacts and other of the signal contacts.

3. The connector according to claim **1**, wherein the plurality of signal contacts include at least one differential signal contact pair consisting of two contacts that transmit differential signals, and

wherein the two contacts constituting the differential signal contact pair are disposed adjacent to each other with no non-signal contact disposed therebetween.

4. The connector according to claim **1**, wherein the signal contacts and the non-signal contacts each has a contact section to be in contact with a contact of a counter connector at a front end thereof, a substrate mounting section to be mounted and fixed to a substrate at a back end thereof, and an insulator fixing section to be fixed to the insulator at a middle portion thereof,

wherein the contact section and the insulator fixing section are formed on a same plane with each other, and

wherein the ground plate faces the contact section and the insulator fixing section of the plurality of signal contacts and the plurality of non-signal contacts.

5. The connector according to claim **4**, wherein the ground plate has a plate body facing the contact section and the insulator fixing section of the plurality of signal contacts and the plurality of non-signal contacts, and at least one plate leg section that is coupled to the plate body to be mounted and fixed on the substrate, and wherein the at least one opening is formed in the plate body.

6. The connector according to claim **5**, wherein the at least one opening consists of a plurality of openings which are disposed correspondingly to the non-signal contacts disposed between each of the signal contacts and other of the signal contacts and disposed between a plate front end portion facing a front end of the contact section of each of the non-signal contacts and a plate back end portion facing a back end of the insulator fixing section of each of the non-signal contacts at a side of the substrate mounting section.

7. The connector according to claim **5**, wherein the at least one opening consists of an opening which is disposed correspondingly to the non-signal contacts disposed between each of the signal contacts and other of the signal contacts and extends between a plate front end portion facing a front end of the contact section of each of the non-signal contacts and a plate back end portion facing a back end of the insulator fixing section of each of the non-signal contacts at a side of the substrate mounting section.

8. The connector according to claim **7**, wherein the plate front end portion corresponding to the non-signal contact disposed between each of the signal contacts and other of the signal contacts is notched so as to open a front end of the opening.

9. The connector according to claim **7**, wherein the plate front end portion and the plate back end portion corresponding to the non-signal contact disposed between each of the signal contacts and other of the signal contacts are notched so as to open a front end and a back end of the opening.

10. The connector according to claim **1**, wherein the ground plate has a lock receiving section which protrudes outward from a location facing the plurality of signal contacts and the plurality of non-signal contacts in an arrangement direction of the plurality of signal contacts and the plurality of non-signal contacts so as to be exposed outside of the insulator and catches a lock section of a counter connector when fitting to the counter connector.

11. The connector according to claim **10**, wherein the lock receiving section has a thickness greater than a thickness of

the ground plate at a portion facing the plurality of signal contacts and the plurality of non-signal contacts.

12. The connector according to claim **1**, wherein the at least one contact array plane consists of a pair of contact array planes formed on both sides of the ground plane, the plurality of signal contacts and the plurality of non-signal contacts being arranged on each of the pair of contact array planes.

13. The connector according to claim **12**, wherein the plurality of signal contacts and the plurality of non-signal contacts arranged on the pair of the contact array planes are disposed symmetrically with respect to the ground plane.

14. The connector according to claim **1**, wherein the plurality of non-signal contacts include at least one of a power supply contact, a ground contact, and a contact for detecting connector-fitting status.

15. The connector according to claim **1**, wherein the plurality of signal contacts, the plurality of non-signal contacts, and the ground plate are insert-molded with a resin used to form the insulator.

16. The connector according to claim **1**, further comprising a metal shell adapted to cover an outer periphery portion of the insulator.

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